The Evolving Process of Technological Innovation and Production Management in Japan after World War II.

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Preface

Industrial production in Japan suffered serious damage in World War II, revived rapidly taking advantage of the Korean War (1950-1953) opportunity, and recovered to the pre-war level by the first half of the 1950'S. After that it had two periods growth by the first half of 1970'S, and became second in industrial production in the capitalist world in the 1960'S.

Meanwhile Japanese industrial goods became strengthened not only in their price competition ability through remarkable cost reduction, but also in non-price competition ability. Thus, they raised their reputation in the international market from "cheap and poor" to "cheap and good".

In this paper I shall try to trace the evolving processes of technological innovation and production management in Japanese Companies until "the oil crisis", both of which are the main factors that contributed directly to the above mentioned developments in industrial production.

1. The Period of Confusion (1945–1948)

(1) Technological Innovation

Reindustrialization in Japan was begun just after the end of World War II, by means of the government policy of raising the level of production of all industry, through the strengthening of fundamental industries such as coal, iron and steel, and electric power. There was extensive financial support by the government, but most of the equipment depended upon the same technologies as before the war.

(2) Production Management.

Financing by the government depended on the overissue of deficit bonds, this caused rapid inflation. Also, the prewar nondemocratic social and economical system, which American occupation forces regarded as the basis of Japanese militarism, were reformed rather radically and "democratically". Workers, suffering from poverty and social uneasiness, were suported by occupation forces, and rapidly organized unions that struggled violently against the executives of companies and the government. Their demands were for higher wages and the abolishment of discrimination between blue and white collar workers. Their struggles in most cases were successful.

Under such disruptive circumstances, most executives lost their desire to improve production efficiency and left production management to take its own course. An exception was the electric companies that supplied communications instruments to The Telegraphic Communication and Telephone Department of the Japanese government. They began to learn and apply the theories and techniques of statistical quality control to their manufacturing porcesses, under the guidance of American experts

belonging to the Civil Communication Section, General Headquaters of Occupation Forces.

2. The Period of Reconstruction (1949–1954)

(1) Technological Innovation

The "cold war" between capitalist and socialist countries, that began around 1947, converted the Japanese occupation policy of the American government from non-militarization and democratization to one of economic reconstruction and rearmament. This new policy was put into concrete practice by relaxing the "Zaibatsu" restrictions and by weakening the Anti-Monopoly Laws, both of which had been enacted as part of the reformation just after the war. Restraints were also placed on the labor unions, the economic supports were reinforced and a retrenchment finance policy was adopted in the government. Japanese companies were able to improve conditions of management through controlled inflation, weakening labor movements, and stabilization in the value of the yen.

Then The Korean war broken out in 1950. Special industrial requirements due to the outbreak of war, gave companies an opportunity to accelerate their activities. The adoption of new production technologies and equipment imported from the West especially from the U. S., were carried out vigorously. By 1954 the production level of Japan recovered to pre-war level.

Important innovations during this period were as follows.

(a) The Electric Power Industry

Construction of the large-scale power plants based on the introduction of the arch-frame dam construction techniques and large-scale ma-

chinery for development work.

(b) The Steel Industry

Introduction of strip mills and oxygen steel-making equipment, and the scaling up of the open-hearth furnace.

(c) The Shipbuilding Industry

Full-scale conversion from the rebetting building method to the welding block building method.

(d) The Automotive Industry

The start of car assembly based on technical cooperation with western makers, and introduction of conveyer systems to the assembly lines.

(e) The Chemical Industry

The start of producing such sophisticated molecular goods as vinyl chloride resins, melamine resin, silicon, medicine and farm chemicals such as penicillin, DDT, and BHC.

(f) The Textile Industry

The start of producing synthetic fibers like nylon, salan, and "Vinylon" that was the only good based on Japanese homemade technology.

(2) Production Management

In parallel with the active promotion of the above mentioned technological innovations, Japanese companies began tackling the problems of production planning and controlling. They pushed them as the keynote of the introduction of modern production management methods which had been developed in the West, especially in the U. S. A.

The main function taken up by these sections was quality control. Their efforts were stimulated by training courses and consultations with such institutions as the Civil Communication Section at Occupation Forces, General Headquarters, The Japanese Standardization Society, and other

such organizations held successively, lectures by such American authorities in this field as W. E. Deming and J. M. Juran, and establishment of the "Deming Prize". by The Union of Japanese Scientists and Engineers in 1951. The prize were intended to award the individual who had greatly contributed to the research and the actual spread of statistical quality control, and the company that had accomplish the most remarkable improvements through the introduction of such methods.

Also in this period statistical quality control began to extend its application from inspection to process control. At that time all of tools related to it like statistical sampling inspection, standardization, histogram, control charts, design of experiment, etc. were used.

The rationalization of process design and operation was actively promoted and second in priority only to quality control. In this period the mass production type assembly industries like automobile and home electric appliances industries adopted the conveyer system into their assembly lines. Since around 1953, the above industries and apparatus industries like steel, and chemical industries had intended to introduce automation into their production processes. Also, the spread of statistical quality control demanded naturally standardization of operation, In such situations, it took a growing need for the rationalization of process design and operation. And as the techniques for that, in addition to the traditional methods like motion study, time study and process study that had been already introduced before The World War II, PTS methods like WF, MTM, etc. were adopted.

Lastly, in regard to information, PCS which used electronic computer were adopted to such operational functions as man-hour calculation, tool calculation, inspection, etc.

3. The Period of First High Growth (1955–1961)

(1) Technological Innovation

Japanese companies that had recovered the productive ability to the level of the pre-war, began to evolve real technological innovation in 1955, and supported with the growth of domestic market, continued to accomplish high growth until 1961.

Consequently, the ability of Japanese industrial production got close to the advanced countries in western Europe. In this period, the technologies in themselves were so holistic and large-scale that the development of them extended beyond an individual industry to the other many industries. Thus, the introduction of new technologies and the massive modernization of equipment was actively carried out throughout the whole industrial system.

The important innovations during this time were as follows.

(a) The Electric Industry

This department was one that evolved the most splendid innovations of all. First, mass production methods to such household appliances as the washing machine, refrigerator, vaccum cleaner, television and stereophonic phonograph were introduced successively in a very short period. Second, the technologies of the semiconductor industry like transisters, and diodes as part of transmitter-receivers and other electronic computers were imported from the U. S. A., and soon was integrated into domestic production.

(b) The Automotive Industry

As for this industry, first, each company began to produce products based on its own design and both capacity and styling came nearer to

international levels. Additionally they introduced the transfer machine into the machining process, and mass production system was on its way.

(c) Other Assembly Industries --- Sewing Machine, Camera and Field Glasses.

As for the other assembly industries, the technology of sewing machine, and camera and field glasses industry, all of which had been improving steadily in quality and cost through adopting the mass production system, had reached level of the advanced countries in each field, and became the foreruner of Japanese exported goods of Japan in this period.

(d) The Chemical Industry

Accelerated by the situation that crude oil prices had fallen steeply due to the successive discovering of the big oil fields in the Middle East since in the early 1950'S, the petrochemical industry was rapidly built up. Its plants, taking the form of industrial complexes equiped with automated instruments, were located at several coastal zones facing the Pacific Ocean.

The formation of petro-chemical industry not only supported a real extention of the production of the synthetic fibers like nylon, vinylon, etc., but also its products were used for materials for other industries such building materials, the machining parts and other miscellaneous goods.

(e) The Shipbuilding and Construction Industries

The increase of imported crude oil and with the developments of the petro-chemical industry, demanded largi-sized tankers, building of fullsized shipways and the construction of harbor facilities. This promoted the development of technology and production in the shipbuilding

and construction industries.

(f) The Steel and Electric Power Industries

The rapid development of innovations in the above assembly and chemical industries, expedited the scaling-up and automation in the two fundamental industries, steel and electric power. In the former, the full-sizing of blast furnaces, the adoption of the basic oxygen furnace, the scaling up, continuation and automation in the rolling process, and the construction of integrated iron and steel works were carried out.

As for the latter, the construction of several large hydro electric plants and the development of big-capacity steam powers plant was accomplished.

(2) Production Management

In concert with the spread of the rationalization of production system through the above mentioned introduction of new technologies and equipment, the rationalization of production management also was carried out more really than during the preceeding period. In this period, the theories and methods of modern management that had been developed in the West, especially in the U. S. A., were adopted very vigorously. Such efforts were made not only in order to solve actual problems, but also as a compaign by the entire Japanese industrial world. This evolved as "The Movement Toward Higher Productivity" under the leadership of The Japan Productivity Center. JPC was established in line with government policy in 1955, and was composed of representatives from employers, labor unions, and scholars and men experience.

In the process of movement, many kinds of observor missions were sent successively to the advanced western countries. Accelerated by subsequent reports of theories and practices on modern managemnt, a

business management boom occured, and through that, many different theories and methods of modern production managent were introduced.

Quality control was adopted much more extensively, but further the concept of Total Quality Control that A. V. Feigenbaum advocated, led to emphasis on the function itself that would achieve succes in the QC Circle later.

Equipment modernization, expansion of productive capacity, and plant construction, caused companies to have a strong interest in plant layout and material handling on which studies had been relatively backward until then. In the advanced companies, the improvement of approaches to plant construction, layout and material handling were carried out through the consultations and directions by American experts like R. Muther, etc. and The Japan Material Handling Society founded in 1956.

Because the neessity for improving productive efficiency grew with the rapid increase of product demand, the modernization of such functions as production planning, scheduling, subcontracting, inventory control, plant maintinance, etc., were promoted as occassional demands of each company.

To solve the above problems not only such techniques of industrial engineering as time study, motion study, process study, PTS, work sampling, etc. were used actively, but also in the advanced companies, such new techniques as operations research, systems engineering, value analysis and value engineering that had been developed through World War II into the post-war in the West, especially in the U. S. A. were adopted as productive practices.

In regard to imformation in production management, the Electronic

Data Processing Systems, that had begun to be installed into the companies early in this period were used for information processing at the control levels like production planning, scheduling, inventory control, etc.

As mentioned, Japanese companies very vigorously adopted almost all of the theories and techniques which had been developed in the West by that period. They greatly contributed to enlightening management interests. However, in actual application the adoptions were limited to partial areas and were not necessarily systematic. Also, the principal promoter of the new techniques were experts who held staff positions.

It can be said, therefore, that Japan was far from modernizing fundamentally production management, though they certainly realized a certain measure of results at the time. And so, generally speaking, a very curious situation materialized: A knowhedge of modern production management penetrated deeply into management interests, but the practices of production management were dependent still on conventional, spiritualistic ways of thinking.

As an example, it was not surprising to observe the following phenomena: production managers were translated theory into action without detailed plannig. As for quality they did not try to assemble finished product by making each part first conform to predetermined, precise standards, but kept instead to the old practice of assembling them one step at a time, depending on the intuitions of skilled workers. Concerning appointed dates of delivery, they were frequently attained at the last moment by overtime and by help from othersections just before the due date.

4. The Period of Stagnation (1961-1965)

(1) Thechnological Innovation

The circumstances in Japanese companies changed remarkably in two ways during the early 1960'S. First, a supply of cheap young labor that had been abundant until then dried up, so that companies were confronted with a sharp rise in personnel expenses. Second, the liberalizations of trade and capital funding that had begun in the late 1950'S, accelernted. Companies were thus urged to strengthen international competitive abilities.

However, in spite of the above inducements to automotive, technological innovations were rather stagnant during this period for the following reasons: previous high growth had raised Japan's reliance on major industrial resources like crude oil, iron ore, coal for material use, lumber etc. Imports rose and since growth, to this point, relied chiefly upon the domestic market, an adverse international balance of payments occured twice from 1961 to 1965.

Such deficits caused actions of money-tightening policies by the central bank of Japan, and plant and equipment investment by companies were restrained. As the result the speed of innovations was markedly reduced.

(2) Production Management

As for management in this period, accelerated by the above actualization of labor shortage and progress of liberalization of trade and capital, the efforts forward rationalization were made so desperately that the modern production management began gradually to get firmly fixed, and foundations that it penetrated into the productive practices in the next

high growth period had been laid. As regards that, I should like to describe it in the next section, along with the production management in the next period.

5. The Period of Second Hight Growth (1966–1973)

(1) Technological Innovation

Japan's economy returned to prosperity in the mid-60's, prompted by large treasury investment loans, and an increasse in exports due to the development of international competitive abilities in heavy industries like steel, household electric appliances, car, etc., and promoted higher growth than in the first high growth period until the occurence of the so called "oil crisis" of 1973. In the above circumstances investments in new techologies and equipment revived.

The first feature of innovation in this period was its large size, At first in the heavy and chemical industries, the pursuit of large size was carried out in almost all departments, and the equipment adopted in their courses were automated and controlled by the computer. Consequently, the products developed international competitive abilities and became leaders in exports. Important technological advances in this period are as follows.

(a) The Steel Industry

Adoption of the super large-sized blast, and basic oxygen furances, and construction of the large-scaled integrated iron and steel works in six coastal regions.

(b) The Chemical Industry

Contruction of the industrial complexes in the eight coastal regions.

(c) The Shipbuilding Industry

Building of the super-sized high-speed tankers.

(d) The Electric Power Industry

Adoption of the large-capacity steam dynamos.

(e) The Automotive Industry

Construction of entire plants for private car use.

In traffic and transportation indnstries, construction of roads for automobile use, the Tokai-Do New Bullet Train Line, the strong Kanmon Bridge and long Rokko Tunnel, skyscrapers, transport planes as jumbo jet planes and the airbus occured. These also hastened innovations in the heavy and chemical industries.

Also, huge projects on neuclear power, space development and ocean exploration that had begun in the latter half of the 1950's, got underway.

The upscaling, automation and computerization of production system, with the adoptation of the above technologies, brought a rapid expansion in plant size. As economics teaches us, plant size is an index that indicates most directly the so called "economies of scale" that contribute to cost reduction. Meanwhile, Japanese major companies, belonging to the heavy and chemical industries, had reached the top level in the world. For example, in the automotive industry, there were five plants with an annual car production capacity of 600, 000 cars in the first half of the 1970's in Japan, while there were only two in Germeny and none in the U. S. A. reached to its level. In steel, there were nine works with an annual crude steel production capacity of more than 6, 000, 000 tons. There were only fifteen in the rest of the world.

Another feature of innovations in this period was the rapid evolution of electronic technologies. That is, Japanese companies imported sucessively IC and LSI circuits, both of which had been developed in the U.

S. A. in the first half of this period, and began soon to produce them themselves. This contributed greatly to quality improvements and cost reductions in products like portable radios, color televisions, desk caluculators, computers, etc.. Not surprisingly these products grew to be the leading exports of Japan.

(2) Production Management

Modern production management that had been getting fixed on productive practices since early in the 1960's, came at last into bloom in this period. That is, the ways of modern production management that had been adopted separately and partially until then began to be integrated into the productive practices and to evolve numerically and synthetically. And in parallel with such a tendency, the principal promoters of modern production management converted from the experts who held staff positions to the line managers.

The internal conditions within the companies which permitted such developments were as follows.

First, quality control and industrial engineering that had been adopted actively until then, penetrated into manufacturing, and value analysis or value engineering that had been adopted chiefly in purchasing section since around 1960, began to have more intimate worth to managers as will.

Second, the applications of operations research and systems engineering to the production problems had spread among and within most companies, along with the increase of the installation of EDPS. Thus, persons concerned in production management got to develop their competencies in order to synthetically and systematically approach production problems.

Third, the rationalization of managerial organization that had begun in the latter half of the 1950's was carried out more realistically in this period. That is, the modernization of such aspects of organization as adoption and/or intensification of line-staff organization, simplification in lines of direction and command, clarification of job content, etc., that had been put in force since the latter half of the 1950's, was tackled vigorously in this period. Particularly in line organization, a modern formanship named "Sagyocho Seido" was adopted in many companies and sharp delegation of authority to the foreman was carried out. In addition, many kinds of systematic training courses on modern management for the foreman and applicants in order to foster greater loyalities to the company and upper management leadership. Many of them had been members of the labor union. Thus, the organizational conditions of modern production management penetrated into productive practices.

Modern production management took root into practices based on the formation of the above internal conditions. By the way, on that occasion it did not assume just the same form as one in its native country, but was modified so as to adopt itself to the situations characteristic of Japanese companies. The following three systems could be cited as representative examples.

(a) QC Circle

The Quality Control Circle is a form of organization that conducts total quality control. It is a small group of employees doing similiar work under one supervisor and meeting regularly to identify, analyze and solve product quality problems. Participation in it is generally voluntary. It seems that such a distributed way of controlling quality is rather different from the Western traditional style which is based on

the principle of specialization.

The QC Circle officially started under the proposal of The Union of Japanese Scientists and Engineers in 1962. It attracted the attention of many companies from the first as a useful system not only for quality and efficiency improvements, but also for motivation, and since then has expanded very rapidly among companies in all kinds of industry. In the circles the fundamental techniques of statistical quality control, industrial engineering, value analysis, etc. are actively taught to and used by the members.

(b) PAC

In the situation that the incentive wage system had been underveloped because of firm survival of hourly rate systems based on traditional seniority criterion, the applications of industrial engineering in Japan, by contrasted with it in the U. S. A., had been given priority to method study over work measurement. This tendency had been one of bottlenecks in modernization of production management, because standard time is a requisite for the conduct of all kinds of production management functions.

The Performance Analysis and Control (PAC), developed by The Japan Management Association early in the 1960's, is a system for improving performance of operation. It did not use money incentives as a means of performance improvement so to be adopted in many companies. Thus, the standard time system extended considerably through that.

(c) Toyota Kanban System

The Toyota Kanban System (TKS), developed by Toyota Motor Company in the early 1960's, is a production and inventory control

system with the object of cost reduction through minimization of work in progress inventory. "Kanban" is a card used as a means of communicating production control information in the plant.

The TKS idea is to deliver subassemblies just in time to go into final assemblies, fabricated parts just in time to go into subassemblies, and raw materials just in time to go into fabricated parts. This avoids having parts delivered before they are needed, only to sit idle while gathering carrying charges. TKS is accomplished by frequent delivery of parts in small numbers. For parts to be delivered in small numbers, they also must be made and bought in small numbers. Thus, TKS parts delivery requires small production and purchase lot sizes. As a result, change-over set-ups are much more frequent. But thanks to work simplification methods, these are accomplished very rapidly and down-time is minimal.

In the situation that companies were not able to pursuit large scale economies since the oil crisis, the TKS has been installed into many companies, especially repetitive manufacturing ones. These companies can be founded in the electric, machinery, chemical and, of course, automotive industries.

Modern production management also penetrated into productive practices through computerization. The installement of EDPS has developed rapidly since the first half of the 1960's. The application of EDPS to production management was promoted since around 1965. In this process many companies gave their efforts chiefly to the rationalization of information processing on such controlling functions as scheduling inventry control, and cost control, and the advanced ones adopted comprehensive information systems integrating all of the functions from

forecasting to shipping.

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